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Assessment of the Subsistence Harvest and Biology of Narwhal (*Monodon monoceros L.*) from Admiralty Inlet, Baffin Island, N.W.T., 1983 and 1986-89

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by

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ABSTRACT

Roberge, M.M., and J.B. Dunn. 1990. Assessment of the subsistence harvest and biology of narwhal (Monodon monoceros L.) from Admiralty Inlet, Baffin Island, N.W.T., 1983 and 1986-89. Can. Tech. Rep. Fish. Aquat. Sci. 1747: vi + 32 p.

In 1983 and 1986-89, the Department of Fisheries and Oceans conducted a survey program of the Arctic Bay subsistence narwhal hunt in Admiralty Inlet, Northwest Territories. Historic reports indicate that harvests of narwhal have fluctuated since 1958. Narwhal were harvested from the end of May to October depending on ice and weather conditions. The annual hunt was divided into three phases: floe edge, ice crack and open water. Over 80% of the harvest occurred during the ice phases. Hunting techniques varied between phases. Male narwhal composed most of the landed catch. Annual harvest statistics underestimated the total numbers of narwhal killed due primarily to the non-reporting of struck and killed but lost whales. Loss rates varied between hunt phases: 32% for the floe edge, 24% for the ice crack and 7% for the open water; all were lower than that reported in a previous study in Pond Inlet. The estimated total kill of narwhal exceeded the reported landed catch by 40%.

Mean morphometric measurements of narwhal sampled from the landed catch differed between the sexes and between narwhal landed in Arctic Bay and Pond Inlet. Fifteen percent of the females examined had tusks. There was no difference in the blubber thickness over the summer season. Narwhal fed primarily on Arctic cod and squid.

Key words: Arctic Bay; feeding; harvest statistics; hunting techniques; marine mammals; Monodontidae; morphometrics.

RÉSUMÉ

Roberge, M.M., and J.B. Dunn. 1990. Assessment of the subsistence harvest and biology of narwhal (Monodon monoceros L.) from Admiralty Inlet, Baffin Island, N.W.T., 1983 and 1986-89. Can. Tech. Rep. Fish. Aquat. Sci. 1747: vi + 32 p.

En 1983 et de 1986 à 1989, le ministère de Pêches et des Océans a mené un programme de relevés de la chasse de subsistance du narval effectuée par des chasseurs d'Arctic Bay dans l'inlet de l'Amirauté, dans les Territoires du Nord-Ouest. Les données historiques révèlent que les captures de narval fluctuent depuis 1958. Ce cétacé est chassé de la fin mai jusqu'en octobre selon la concentration de glace et les conditions météorologiques. La chasse annuelle est divisée en trois phases: à partir des floes, dans les fissures de la glace et en eau libre. Plus de 80% des activités de chasse ont lieu pendant les périodes de présence de glace, tandis que les méthodes de chasse varient d'une phase à l'autre. La plupart des animaux tués sont des mâles. Les statistiques annuelles sur les captures ne sont pas représentatives du nombre total de narvals tués, surtout parce que le nombre d'animaux tués et perdus n'est pas signalé. Le taux de perte varie selon les phases de la chasse: 32% dans le cas de la chasse à partir des floes, 24% dans le cas de la chasse dans les fissures et 7% dans le cas de la chasse en eau libre. Ces taux sont inférieurs à ceux signalés par un étude sur la chasse du narval fait auparavant par le ministère à Pond Inlet. Le nombre total estimatif d'animaux tués est de 40% supérieur aux captures débarquées signalées.

Les caractéristiques morphométriques moyennes des narvals échantillonnés dans les captures débarquées montrent un dimorphisme sexuel et une différence entre les narvals capturés par les chasseurs d'Arctic Bay et ceux de Pond Inlet. Chez les femelles échantillonnées, 15% portaient des défenses. Aucune différence de l'épaisseur du pannicule adipeux n'a été relevée pendant l'été. L'étude des contenus stomacaux a révélé que les narvals se nourrissaient surtout de calmars et de saïdas francs.

Mots-clés: Arctic Bay; alimentation; statistiques sur les captures; méthodes de chasse; mammifères marins; Monodontidae; caractéristisques morphométriques.

INTRODUCTION

The Department of Fisheries and Oceans (DFO) has identified three summering narwhal (Monodon monoceros) management stocks: northwest Greenland, northwestern Hudson Bay and the Canadian High Arctic (Strong 1988) (Fig. 1). The Canadian High Arctic stock summers in the inshore waters of northern Baffin Island, Northwest Territories (N.W.T.) including the waters of Eclipse Sound, Admiralty Inlet, Prince Regent Inlet and Peel Sound.

Narwhal are endemic to the Arctic and are seldom seen south of 65 N (Strong 1988) (Fig. 1). During the winter, narwhal are found in the open waters in Baffin Bay and Davis Strait in close association with pack ice (Davis et al. 1979; Kapel 1977; Mansfield et al. 1975a,b; McLaren and Davis 1981). In spring, they migrate northward as the ice recedes along the west coast of Greenland and then in June and July westward to Lancaster Sound, Jones Sound and Pond Inlet (Greendale and Brousseau-Greendale 1976; Johnson 1976). As the ice breaks up narwhal move from Lancaster Sound into Eclipse Sound, Navy Board Inlet and Admiralty Inlet (Davis et al. 1979). In the fall, as the waters of the Arctic Archipelago freeze, they migrate east and south along with the movement of the sea ice (Davis et al. 1978; Finley and Johnson 1977).

The management of narwhal is administered under the authority of the Fisheries Act and the Narwhal Protection Regulations. The Narwhal Protection Regulations were introduced in 1971 restricting Inuit to five landed narwhal per hunter per year. In 1977, after consulting with each settlement with a recorded historical use of narwhal, DFO established an annual community quota, based on local needs and limited biological information (Finley et al. 1980; Weaver and Walker 1988). As well, female narwhal with calves are protected and wastage of meat is discouraged. The quota is controlled through a tag system which specifies the number of narwhal that can be landed; it was designed to protect the narwhal populations in the N.W.T. and to ensure the continued availability of the resource to Inuit. Initially the N.W.T. narwhal quota was 402. In 1978, the quota increased to 472 narwhal and with subsequent increases it currently stands at 525 whales.

The quota system was designed to record only narwhal landed and did not consider those whales struck and killed but not landed (lost). This has resulted in an underestimation of the annual removals from the population. Information on struck and loss rates are scarce and available only for the Pond Inlet narwhal hunt (Finley and Miller 1982; Finley et al. 1980; Weaver and Walker 1988). The largest community quota (100 narwhal) is issued only to the communities of Pond Inlet and Arctic Bay. The Arctic Bay Hunters and Trappers Association (Ikajutit HTA) usually determine the number of narwhal to be taken during each hunt phase before the annual hunt begins; the usual ratio being 70 from the floe edge/ice crack phases and 30 from the open water phase.

Arctic Bay residents harvest narwhal from the Admiralty Inlet and Lancaster Sound areas (Fig. 2). Information on narwhal utilizing Admiralty Inlet is sparse. Hay (1984) documented the life history and basic biology of narwhal frequenting the coastal waters of northern Baffin Island. Biological data collected from 25 narwhal landed during the 1975 open water hunt is discussed by Hay (1984) and Hay and Sergeant (1976). Catch statistics for the community of Arctic Bay appear in Bissett (1968), Degerbol and Freuchen (1935), Hay (1984), Kemper (1980), Mansfield et al. (1975b), Mitchell (1982), Mitchell and Reeves (1981), Reeves (1977b) and Strong (1989). Description of the hunting techniques for the open water phase of the hunt is provided by Hay and Sergeant (1976), Kemper (1980) and Reeves (1977a,b).

In 1986, DFO initiated a program in Arctic Bay to document current hunting techniques, determine struck and loss rates and collect biological data on the exploited segment of the narwhal population. In this report we summarize our observations of the 1986-89 hunts as well as data collected by DFO from the 1983 hunt and use this information to estimate total annual kill. Morphometric data are used to compare narwhal harvested in the Admiralty Inlet and Pond Inlet areas.

HISTORY OF THE HUNT

Arctic Bay is a community of approximately 500 residents, located along the north shore of Adams Sound in Admiralty Inlet (Fig. 2). Prior to the establishment of the community in the mid 1960's, Inuit traditionally lived throughout the Admiralty Inlet region and came to Arctic Bay area seasonally to hunt narwhal for food and clothing. Inuit used narwhal meat to feed their dog teams (Kemper 1980; Reeves 1976; Reeves 1977a; Reeves and Mitchell 1981). Blubber was used to fuel lamps and cooking fires (Reeves 1977a; Reeves and Mitchell 1981). Muktuk (or narwhal skin), high in Vitamin A, was and still is an important food item. Historically the muktuk was occasionally dried and used as leather thongs and dog traces (Reeves 1977a). Narwhal sinews served as thread for sewing garments and binding leather implements (Reeves and Mitchell 1981). The ivory from the tusks was used for making harpoon tips, lances and sometimes carvings (Reeves 1977a). Today most traditional uses of narwhal

products have declined, particularly that of meat since skidoos are steadily replacing sled dogs for transportation (Bissett 1968). Limited amounts of meat and muktuk may be utilized through intersettlement trade. Some narwhal meat may be cached for use as fox bait during the winter (Finley and Miller 1982; Kemper 1980; Reeves 1977a; Reeves and Mitchell 1981). Tusk ivory is now used primarily for commercial sale and to a lesser extent for carving. Hay and Sergeant (1976), Kemper (1980) and Reeves and Mitchell (1981) state that the increased landed catch of narwhal in the recent past is due to the increased dollar value of the tusk.

Historical records of the subsistence narwhal harvest in the Admiralty Inlet region are scarce. In 1873, Captain William Adams, a Scottish whaler, left Adams Sound with 27 narwhal harvested from the Admiralty Inlet-Lancaster Sound area (MAB 1987). In the early 1900's, trading posts were set up in the Pond Inlet area (Mitchell and Reeves 1981) and Inuit from the Admiralty Inlet area went there to trade. Degerbol and Freuchen (1935) reported that a "savssat" (an ice entrapment of cetaceans) occurred in southern Admiralty Inlet near Moffet Island in 1924, from which at least 400 narwhal were landed. In 1926 the Hudson Bay Company built a trading post in Adams Sound, Admiralty Inlet and reported a harvest of 27 narwhal (Mitchell and Reeves 1981). The post was closed in 1927 when the Arctic Islands Game Preserve was set up to protect the declining musk-ox population; although the Adams Sound post was reopened in 1936 with the resurgence of the musk-ox population, no published records of the trade in narwhal products are available. The harvest of narwhal in the Arctic Bay area from 1955-1989 is depicted in Fig. 3.

METHODS AND MATERIALS

DFO staff monitored the Arctic Bay narwhal hunt in 1986 and 1987 with the assistance of local guides (and known narwhal hunters) from the community. In 1988, the monitoring program was modified to hire and train local narwhal hunters as monitors to collect data for DFO. DFO staff conducted training sessions to instruct the monitors in the collection of both hunting event information (Appendix 1) and biological sampling data (Appendix 2).

The hunt was divided into three phases based on sea ice conditions, (which in turn varies the time and success of the hunt): floe edge, ice crack and open water as described by Finley et al. (1980), Finley and Miller (1982), Kemper (1980) and Weaver and Walker (1988).

Data were obtained from the 1977-1989 landed catch from tag records provided by the Ikajutit HTA. The HTA identified the date of each kill and usually the sex of the narwhal. The kill dates were used to estimate the numbers of narwhal landed in each hunt phase. Hunt phases were arbitrarily separated by locating significant gaps between kill dates and examining yearly ice conditions. This information along with the sex data was used to estimate the sex composition of the harvest in each hunt phase.

HUNTING EVENTS

The term "hunting event" used in documenting the harvest represents the action of taking aim at target narwhal by one or more hunters (Weaver and Walker 1988). Hunting events were either directly observed by DFO staff, recorded through DFO hunter interviews or recorded by a monitor (directly or indirectly). Information collected by hunt phase included the location and timing of hunting events, the range from which shots were fired, the number of shots and calibre of rifle used as well as the number of narwhal shot at.

Narwhal struck in each event were either recorded as landed, wounded or sunk. Wounded narwhal were identified as either superficially wounded or mortally wounded after direct observation and discussion with the hunter. Classification follows that described by Weaver and Walker (1988) for the "critical (lethal) window", firing distances and angle of fire, all used in determining the wound type.

Struck loss rate

Struck loss rates, or the number of narwhal struck and killed but not landed, were estimated by the ratio of the combined numbers of narwhal mortally wounded and sunk to the total numbers of narwhal struck.

Kill:landed estimator

Kill:landed estimators were estimated by the ratio of the number of narwhal killed including the number landed, mortally wounded and sunk to the number of narwhal landed. Estimators were calculated to incorporate the struck loss rates into estimates of total narwhal removals; the total annual number of narwhal landed was multiplied by the estimator to provide a corrected total of annual removals. The jackknife procedure (Efron and Gong 1983), described by Weaver and Walker (1988), was used to estimate a corrected kill:landed estimator which would reduce the statistical bias associated with the original estimator. Since observations were not available for all years or all hunt phases, estimators were pooled by hunt phase.

BIOLOGICAL SAMPLING

Each sampled narwhal was assigned a unique catalogue number, sexed and measured. Morphological measurements including total body length (straight length), fluke width, girth (axillary and umbilical), flipper length (anterior and axilla), flipper width, exposed tusk and total tusk lengths and basal tusk circumference were recorded to the nearest centimeter (Appendix 3). Muktuk and blubber thicknesses were measured to the nearest millimeter along the axillary and umbilical circumferences at the mid-dorsal,-lateral, and -ventral positions (Appendix 3).

Tissue samples were collected opportunistically in 1986 and 1987 for future analysis by DFO scientists. Samples were obtained from the liver, spleen, kidney, heart, muscle, muktuk and blubber for contaminant and genetic analyses.

In 1986 stomachs of the sampled narwhal were removed, frozen and later examined in the laboratory. In 1987 a qualitative analysis of narwhal stomach contents were conducted in the field. Food items were coarsely identified as squid, fish or invertebrates.

DATA ANALYSIS

Data analysis were performed on a micro Vax II computer using the Statistical Analysis System (1985) package. Statistical tests used to analyze both the hunt event data and the biological data included chi-square to test for differences in frequency distributions, T-test and analysis of variance to test for significant differences in means and linear regression to test for correlations. The critical level for all tests was set at 0.05.

RESULTS AND DISCUSSION

HUNTING TECHNIQUES

The hunting techniques observed during the floe edge and ice crack phases are essentially the same. Basic equipment used by hunters consisted of a high powered rifle, hard point ammunition, a grappling hook and harpoon for retrieving and securing the narwhal and a block and tackle or 'come-a-long' to haul the whale out of the water.

Hunters positioned themselves along the ice edge, initially standing back from the edge so their shadows did not alert narwhal swimming below. When narwhal approached, the hunters moved towards the ice edge and waited for a 'good shot'. A good shot required that a narwhal:

a) be within retrieval range (5-10 m), and
b) present a 'good target' i.e. maximal exposure of the lethal window (area bounded by the eye and a point 40 cm behind the flipper), as determined by their swimming behavior. Narwhal surface at regular intervals to breath and expose only a small portion of the head and blowhole area. However prior to deep diving narwhal raise their backs high out of the water and present a larger portion of the lethal window. A successful shot in this area was likely to result in the breaking of the spine or to lodge a bullet near the base of the skull (Weaver and Walker 1988). If the shot missed the pleural cavity it was expected that the whale would float since its lungs were likely full of air.

Shots were usually fired from the standing position but sometimes from a kneeling position; the latter steadies the rifle but decreases the angle of incidence of the shot thereby decreasing its lethality. Non-lethal shots usually resulted from:

a) missing the whale entirely,
b) the bullet hitting the water and deflecting the shot off-target and/or reducing its penetrating power, or
c) missing the lethal window area.

Killed narwhal were observed to be retrieved using a sharpened 3- or 4- pronged grappling hook thrown out and over the animal and pulled back to snag it. The whale was pulled to the ice edge, secured with a harpoon and a hole then cut in the forehead just above the premaxilla so a heavy rope could be tied to the carcass. A 'come-a-long' or block and tackle was anchored to the ice and attached to the rope to pull the whale onto the ice. The carcass was flensed of the muktuk, and it's tusk (if present) and other body parts removed and packed on to the komatik for transportation. S. Akeeagok (DFO, Iqaluit, personal communication) has observed narwhal carcasses being secured with a rope around the caudal peduncle and then pulled out; this method was not observed by the authors.

Floe edge

Techniques specific to the floe edge hunt varied with ice conditions. If the floe edge was free of pack ice, whales were difficult to kill for two reasons. First, hunters were unable to gain an elevated vantage point to decrease the angle of incidence of the shot and second, whales did not usually swim close to the ice edge. Consequently, shots were fired from greater distances and had a lower angle of incidence, which increased the probability of

wounding. Retrieval of whales was also difficult and usually required a boat. Without a boat hunters relied on grappling hooks and since carcasses were often out of range, this resulted in more sunk and lost whales.

It was observed that if the floe edge was ice packed, hunters searched the pack ice for accessible open pockets of water close to the floe edge where they waited for narwhal to appear. Usually hunters were able to find elevated pieces of ice allowing a good shot by increasing the angle of incidence. No observations were made on narwhal landed this way but hunters indicated that when they did land a whale it was quickly flensed on the pack ice. A komatik was then pulled by hand to and from the flensing site to retrieve the muktuk and tusk.

Ice crack

The ice crack hunt usually occurred when the floe edge became too dangerous to travel (i.e. thin rotten ice) or there was a danger of the floe edge ice pan separating from the more land fast ice. Hunters usually positioned themselves along the ice cracks when narwhal moved through. The cracks were normally 10-20 m wide but we observed narwhal in cracks as narrow as 3 m wide. Retrieval of narwhal was not difficult since the whales were usually within range of the grappling hook. Hunters would not shoot at all narwhal, but rather waited for a 'good shot' since crack hunting allowed them to be more selective. Resting narwhal were not usually shot at because they did not present the 'lethal window' and it was often difficult to determine whether or not they had tusks (S. Ageeagok, DFO, Iqaluit, personal communication). As well since their lungs may not be completely full of air there was an increased probability that the narwhal would sink when killed.

During observations of the floe edge/ice crack hunts certain activities were noted that concerned the authors. One such activity was that at times hunters were not prepared to retrieve a whale and did not have a hook or harpoon ready (i.e. a hook or harpoon not present or if present the rope would be tangled). It was also noted that if a large number of narwhal appeared the hunter(s) would not always take proper aim or wait for a good shot which resulted in wounded or sunk whales.

Open water

Open water hunting techniques observed in 1983 did not differ from those described for the Pond Inlet open water hunt (Weaver and Walker 1988). Boats were often used cooperatively to drive whales into shallow water; a practice which was believed to reduce hunting losses. Arctic Bay hunters would fire into the water a few times to scare the whales inshore if necessary, but mostly hunters depended upon the noise of the outboard motor to herd the whales towards shore (Reeves 1977b).

In 1983, single hunting parties were often observed by DFO staff to pull up on drifting ice pans to wait for passing narwhal. If killed in the shallow waters, hunters either used a grappling hook to snag the whale and tow it to shore or depended upon the tide to wash the carcass ashore (Reeves 1977b). Narwhal, if killed in deeper water, were harpooned and a buoyant float attached. Losses due to sinking were prevalent in the deeper waters.

HUNT PHASES

Floe edge

In 1983 the floe edge hunt occurred from 21 May to 17 June. The hunt was not monitored and no whales were sampled. In 1986, the hunt, located at the northern edge of Admiralty Inlet, commenced the week of 25 May (Fig. 2). DFO staff monitored the hunt from 14-25 June during which time no narwhal were landed. Toward the latter part of June, whales were sighted in cracks by the floe edge but ice conditions during this period precluded a successful hunt. No narwhal were landed in this phase of the 1987 annual hunt because the floe edge was remotely located near Navy Board Inlet. Because of the distance from Arctic Bay few hunters attempted the trip. Travel to Navy Board was hazardous due to the rough ice conditions, particularly in areas where Admiralty Inlet and Lancaster Sound met. In 1988 hunting occurred within the northern end of Admiralty Inlet. Monitors surveyed the hunt from 30 June to 5 July but no narwhal were sampled. Information was collected from 7 hunting events (Table 2). In 1989 the floe edge hunt was conducted from 21 June to 11 July at the northern end of Admiralty Inlet; monitors surveyed the hunt from 22 June to 11 July. Information was collected from 21 hunting events (Table 2).

Ice crack

In 1983 the ice crack hunt occurred from 5 July to 25 July. The hunt was not monitored and no whales were sampled. In 1986 the hunt took place in the northern portion of Admiralty Inlet between Elwin Inlet and Ship Point during the first half of July (Fig. 2). The major portion of this hunt occurred between 6-10 July when 76 narwhal were landed. DFO staff monitored the hunt during this same interval. No hunting event data were collected owing to continually changing locations and unstable ice conditions resulting in high mobility of hunters. It was often by chance that a hunter, who had just landed a narwhal, was encountered. Often the whale had already been flensed which precluded

the collection of morphometric measurements. In 1987 the ice crack hunt occurred from 29 June to 18 July at the northern end of Admiralty Inlet and along the southern shore of Lancaster Sound. DFO staff monitored the hunt from 5-17 July. Fewer than normal numbers of narwhal were harvested due to poor ice and weather conditions, however information was collected from 24 hunting events (Table 2). In 1988 the hunt occurred from 23 June to 9 July at the northern end of Admiralty Inlet. Monitors surveyed the hunt during this interval and information was collected from 24 hunting events (Table 2). In 1989 the hunt occurred from 23 June to 13 July at the northern end of Admiralty Inlet. Monitors surveyed the hunt during this same interval and information was collected from 49 hunting events (Table 2).

Open water

This hunt phase was dependent on weather and freeze-up conditions and the number of remaining tags. This phase was not observed by the authors; however in 1983 observations made by DFO staff indicated this phase was conducted from either the community or from land based camps along the western side of Admiralty Inlet (Fig. 2). Reeves (1977b) identified base camps at Naqsakuluk, Ako and Kakiak.

In 1983 the open water hunt occurred from 6 August to 15 September. DFO staff monitored the hunt from 6-20 August and information was collected from nine hunting events, seven of which were observed by DFO staff (Table 2). In 1986 the open water phase occurred from 2 August to 20 September. This hunt was not monitored and no narwhal were sampled. In 1987 the hunt occurred from 29 July to 31 August. The high winds encountered on the west coast of Admiralty Inlet (the major open water hunting area) during August made hunting very difficult. Since breakup of the ice was very slow due to the cool weather in August, as well as the late movement out of the area of the broken ice, hunters had moved into southern Admiralty Inlet to commence caribou hunting and Arctic charr fishing (D. Kalluk, Arctic Bay, personal communication). These factors combined to make for a poor open water hunt in 1987. The hunt was not monitored and no narwhal were sampled. In 1988 the hunt occurred from 15 July to 6 October. Monitors surveyed the hunt from 22 July to 6 October and information was collected from 19 hunting events (Table 2). In 1989 the hunt occurred within Admiralty Inlet from 2-21 August. The hunt was not monitored and no narwhal were sampled.

HUNTING EVENTS

Narwhal were observed struck from mean firing distances ranging from 3.3 m to 22.9 m (Table 2). Finley and Miller (1982) suggested that narwhal were usually mortally wounded if the firing distance was <20 m and superficially wounded if firing distance was >20 m. Weaver and Walker (1988) determined the crucial firing distance to be 25 m. We noted during both the floe edge and ice crack hunts that if the firing distance was less than 25 m and if the angle of firing was low and the whale was not directly in front of the hunter it resulted in superficial wounding of the narwhal.

Reeves (1977b) reported that Arctic Bay hunters use only the .303 rifle. Our results support this observation; 63% of hunters used .303 calibre, 12% used the .375 calibre and 11% used a 6.5 calibre (Table 1). Finley and Miller (1982) reported that the .303 was most commonly used by Pond Inlet hunters; Kemper (1980) found that the .303 and the .30-06 were used during the floe edge hunt in Pond Inlet. Hard point ammunition is the most commonly used ammunition (87%) by Arctic Bay hunters however the less effective soft point ammunition is still being used (13%) (Table 1). Use of soft point ammunition usually results in the superficial wounding of a narwhal likely resulting from reduced penetration.

HARVEST

Landings

Kemper (1980) found that the early harvest of narwhal from the N.W.T. was not well documented. Little information is available for the historic subsistence harvest of narwhal from the Admiralty Inlet area (Fig. 3). Strong (1989) reports recorded landings of narwhal from 1958 to 1987 but states that these statistics are not necessarily the actual harvests and do not include corrections for lost or unreported harvests. The reported average annual harvest from 1955-1958 was 45 narwhal; there is no information on landings from 1959 to 1972 which likely reflects a lack of records rather than a lack of narwhal. Kemper (1980) reported fluctuating harvest statistics for narwhal landed in Pond Inlet during the period 1956-78 and believed similar trends occurred in Arctic Bay. Average annual harvest from 1973 to 1976 as reported in Strong (1989) was calculated to be 109 narwhal. There is a discrepancy in the reported harvest statistics for 1973 and 1974: Mansfield et al. (1975b) reported 150 narwhal landed in 1973 while Strong (1989) reported 101 whales landed and Reeves (1977b) reported at least 200 landed in 1974 while Strong (1989) reported 52 narwhal landed. Using the larger numbers, the average harvest between 1973 and 1976 increases to 158 whales. Hay and Sergeant (1976), Kemper (1980) and Mansfield et al. (1975b) believed the increase in the landed recordings in the 1970's was probably due to the increase in the value of the price of the tusk ivory. However, since 1977, the average

recorded annual landing has decreased to 79 narwhal. Even with the increase in the price of ivory and the intent to increase the landings of narwhal from historic harvest levels, hunters are often restricted not by law but by ice and weather conditions.

Bissett (1968) believed that fluctuations in the number of narwhal landed were due to the annual variations in ice conditions, timing of ice breakup and movement of the narwhal herds. Harvest in the early part of the season was influenced by the conditions of the ice, while hunting in the latter part of the season was influenced by the amount of open water and wind conditions, as well as the number of days available for open water hunting. Finley and Miller (1982) also found ice conditions strongly effected the timing and duration as well as the success of the hunt. Meanwhile Reeves (1977b) observed that in 1974 >100 tusks were taken during the ice edge hunt in Admiralty Inlet while in 1977, due to poor ice conditions, only 10 tusks were taken before the ice broke. During 1987, the Arctic Bay narwhal hunt was very poor due to poor ice and weather conditions (D. Kalluk, Arctic Bay, personal communication). The late breakup greatly reduced the harvest and only 18% of the previous four year average for ice crack harvests was taken. Therefore it is believed that fluctuations in the narwhal harvest from the Admiralty Inlet area were probably related to changing ice and weather conditions.

Sex ratio

The sex ratio of narwhal harvested from 1979 to 1989 by Arctic Bay hunters fluctuated annually (Fig. 3); however for most years males predominated (>75%). Sergeant (1982) attributed the variation in the sex ratio of landed narwhal to hunter discrimination. Finley and Miller (1982) believed that the annual variation in the sex ratio of the landed catch in Pond Inlet was due to hunter discrimination, seasonal emphasis (i.e. muktuk vs ivory) and the success of other hunt phases.

The proportion of landed males:females reported by the Arctic Bay HTA for 1986-89 were similar to that observed during our study (Fig. 4). Males composed an average 80% of the annual harvest for the years 1986-87 and 1989 but a significant decrease (59%) occurred in 1988. The observed data shows a similar trend. The 1988 decrease is believed due to hunter discrimination; the Arctic Bay Co-op processed muktuk for sale to local residents and consequently hunters were paid for their muktuk and thus were less selective towards tusked narwhal (i.e. males).

The sex ratio of landed narwhal from Arctic Bay varies among years for the same type of hunt (Table 3) which is similar to that found by Finley et al. (1980) for narwhal harvested from Pond Inlet. This is due primarily to hunter selectivity and seasonal emphasis.

Floe edge: The sex ratio of narwhal taken at the floe edge from 1983-89 by hunters from Arctic Bay varies (Table 3) and is likely due to hunter selectivity. The 1988 decrease is believed due to hunter discrimination resulting from the Co-op muktuk processing initiative.

Ice crack: The ice crack hunt in Admiralty Inlet from 1983-89 (excluding 1988) consisted primarily of male narwhal (Table 3) similar to that found by Reeves (1977b). Finley and Miller (1982) found that large males tend to move through the ice cracks before females. At this time the whales are vulnerable to the hunter and males with large tusks are easy to select. Females are usually taken at this time either by mistake when firing at a male or for their skin. Finley and Miller (1982) suggested that the high percentage of female narwhal in the ice edge hunt from Pond Inlet was due to females and their calves straying close to the ice edge providing good targets and the hunter's requirements for muktuk being of higher priority at this time. In 1988 the predominately male catch from both the floe edge and ice crack hunts shifted towards females due to hunter selectivity resulting from the Co-op muktuk processing initiative.

Open water: From 1983-89 (excluding 1987) the sex ratio of the open water narwhal harvest was approximately 1:1. This may be due to the presence of females and their calves providing good targets or to the hunter's requirements for muktuk being of higher priority at this time.

STRUCK LOSS RATES

Catch statistics underestimate the number of narwhal killed due to the non-reporting of narwhal struck and killed but lost (not retrieved) (Finley and Miller 1982; Hay 1984; Kemper 1980; Mansfield et al. 1975b; Reeves 1977b; Sergeant 1982; Weaver and Walker 1988). Consideration must be given to the type of hunt phase, the ice and weather conditions and, in particular, to the subjectivity involved in classifying a whale as superficially or mortally wounded. The latter requires an interpretive decision on the part of the observer and in some instances may be difficult. Our study followed the classification criteria described by Weaver and Walker (1988) for superficial and mortal wounds.

Floe edge

The loss rates for the floe edge hunts in 1988 and 1989 varied from 40% to 24% respectively and averaged 32% (Table 4). No estimate is

available for the 1987 floe edge hunt since no hunt occurred due to poor ice conditions. The high loss rate in 1988 was due to the high proportion of narwhal sinking; an estimated 50% of all narwhal considered killed were not retrieved and hunt monitors provided no reasons for this. Our data show that 75% of these narwhal were shot within 3.2 m and therefore could have been secured before sinking. Poor ice conditions may have prevented the hunters from getting a boat in sufficient time to retrieve a dead whale. In comparison the loss rates for Pond Inlet floe edge hunt ranged from 56% (1982) to 27% (1983) (Weaver and Walker 1988); the reduction in loss rates between the two years was believed due to a local hunter initiative in reducing loss rates.

Ice crack

The average loss rate for the ice crack hunts from 1987-89 was 24% ranging from 19-32% (Table 4). The high loss rate (32%) in 1988 is due to the high portion of whales mortally wounded and sunk (17/25); monitors provided no reason for the increase. In comparison the Pond Inlet ice crack loss rates ranged from 10% to 100% (1983 and 1982, respectively) (Weaver and Walker 1988).

The proportion of narwhal sunk during the ice crack hunt is considerably lower (7/17) than that at the floe edge hunt (7/8). This is likely due to easier retrievability of whales at the ice crack compared to the floe edge and not necessarily to inefficiency of the hunters.

Open water

The open water hunt appears to be the most efficient hunt phase, with an average loss rate of 7% (1983 and 1988) (Table 4). This low rate is likely due to the hunting technique used during the open water harvest. There were no whales sunk and lost in either the 1983 or 1988 open water hunts. In comparison the Pond Inlet open water hunt loss rate in 1982 was estimated to be 42% (Weaver and Walker 1988).

Kill loss rates

Past studies in the Pond Inlet area expressed loss rates in terms of total number killed (ie. the ratio of the number of narwhals mortally wounded and sunk to the total number of narwhals killed) and not in terms of total number struck (Finley et al. 1980; Finley and Miller 1982); this expression did not take into consideration those whales struck but superficially wounded and resulted in a higher estimate of loss rate. To compare with these earlier studies we estimated loss rates based on number killed. The average loss rate during the Arctic Bay floe edge hunt was 37% which was lower than the 69% for the Pond Inlet floe edge hunt reported by Finley et al. (1980). Loss rate for the Arctic Bay open water hunt averaged 11% while Finley et al. (1980) estimated a 25% loss rate during the 1978 Pond Inlet open water hunt. Hay and Sergeant (1976) determined a 15% loss rate in 1975 while Kemper (1980) estimated a 20% loss rate for the Pond Inlet open water hunt. Loss rates for the open water hunt conducted in Creswell Bay was estimated to be 17-23% (Finley et al. 1980).

ESTIMATED TOTAL KILL

Kill:landed estimators

The narwhal harvest is regulated by a quota and only reports whales actually landed. A proportion of all narwhal struck are in fact killed as a result of sinking loss or mortal wounding (Fig. 5). Weaver and Walker (1988) state that the kill:landed estimator depends on knowledge of the outcome of hunting events in which whales are struck, and especially on observations of whales struck and landed in each hunt phase. A separate estimator for each hunt phase must be calculated since the accessibility and retrieval possibilities vary between hunt phases.

The struck and loss rates from Arctic Bay indicate that more narwhal are killed but lost during the floe edge hunt (32%) than from the open water hunt (7%) (Table 4). Sergeant (1982) stated that each hunt phase varies annually in extent and between major hunting settlements. Because of this variability, data must be collected over a number of years and hunt phases and the basic requirement of estimating total removals should be that individual estimates are used for each type of hunt.

Floe edge: The pooled (1988-89) estimator (corrected) for the floe edge hunt was 1.56; annual estimators ranged from 2.08 in 1988 to 1.29 in 1989 (Table 5). In comparison the average kill:landed estimator for the Pond Inlet floe edge hunt was 1.45 (Weaver and Walker 1988). Because of the variation in estimators between years, additional data must be collected from the floe edge hunt so that a more realistic and accurate trend in estimators can be determined.

Ice crack: The pooled (1987-89) estimator for the ice crack phase of the annual hunt was 1.41 (Table 5). Weaver and Walker (1988) calculated a similar ice crack estimator for Pond Inlet (1.48). Estimators were similar in 1987 and 1988 (1.50 and 1.56, respectively) but decreased to 1.26 in 1989. It is reasonable to use the average of 1.41 in estimating total kill estimate for the ice crack hunt however additional data must be collected to increase the precision of the mean.

Open water: The open water hunt estimator for 1988 was 1.07, and we have no data from this study with which to calculate another (Table 5). The estimator calculated for the 1983 Arctic Bay open water hunt was slightly higher at 1.18. The pooled estimator of 1.11 is probably realistic, however additional data must be collected to improve on the estimate. The estimator for the Pond Inlet open water hunt (1.93) is almost double that found in Arctic Bay.

Total kill

Using the pooled kill:landed estimators, the estimated total number of narwhal killed was 39% (n=139) greater in 1986 than that reported landed, 35% (n=35) in 1987, 52% (n=131) in 1988 and 25% (n=125) in 1989 (Table 5). Pooled estimators for the floe edge and ice crack hunts from the 1987-89 hunts used in the 1983 data resulted in an estimated 38% (n=138) more narwhal killed than reported landed.

When between year data are pooled, an average 38% more narwhal are killed than reported landed. This is lower than that reported by Davis et al. (1980) and Mansfield et al. (1975b) who believed that an additional 50% of narwhal reported landed were killed but lost. Mansfield et al. (1975b) believed that the high loss rate was due to shooting the whale before harpooning.

The quota for landed narwhal is controlled through the issuance of tags. These tags were designed to easily attach to the tusk of the narwhal. Finley and Miller (1982) and Weaver and Walker (1988) believe that a tag system does not ensure that all female narwhal landed are reported since most female narwhal do not have tusks; in our study only 5% of tusked whales were females. Sergeant (1982) stated that the catch statistics under-report the actual catches because tuskless females are not reported in some communities in some years. Kemper (1980) stated that female narwhal are not always tagged and therefore not reported resulting in an underestimate of annual harvest. He felt that the only real advantage of the tag system was in monitoring the sale of tusks. A sold tusk must have a tag to authenticate the tusk and to validate the sale. In the past there may have been lapses in reporting the number of females actually landed but we believe the reported harvest from Arctic Bay during the study period 1986-89 is accurate due to the strict monitoring of the hunt by the HTA.

The percentage of females reported landed has fluctuated over the years. Finley and Miller (1982) believed this variability is due to the discrimination of the hunters, their seasonal requirements and success of the various phases of the hunt. Unfortunately even if the number of females killed is known there is still an additional fraction of the population which is lost as a result of these kills. Finley and Miller (1982) estimated that at least 39% of female narwhal observed landed in 1979 were pregnant and Hay (1984) estimated 38% of all females landed were pregnant. Weaver and Walker (1988) found that 44% of female narwhal examined from the Pond Inlet hunt in 1982-83 were either carrying full term foetuses (25%) or were newly pregnant (19%). An additional three females were not pregnant but lactating and the accompanying calf probably starved to death (Hay 1984; Finley and Miller 1982). These data appear to indicate that approximately 40% of all females landed will either be pregnant or have a calf in attendance thus making the estimate of narwhal killed annually even higher. Reproductive data were not available during our study but we believe that additional narwhal (calves and unborn narwhal) were likely lost to the population. Therefore the estimated total kill of narwhal from Arctic Bay are higher than reported in Table 6. Using the average estimate of 40% females affected to estimate additional kills, the revised estimates of total kills for Arctic Bay are 141 in 1983, 149 in 1986, 40 in 1987, 145 in 1988 and 134 in 1989.

BIOLOGICAL SAMPLING

Morphological measurements

All females sampled were adult, however 5% males examined were determined to be subadults (Table 6); three of which had tusks. Finley and Miller (1982) believed that the presence of immature males in the landed catch may reflect the tendency of hunters to select animals with tusks even if the whale is small sized. This practice should be avoided if at all possible to ensure that the pre-recruits make it into the fishery.

There was no significant differences ($P>0.05$) between years for any measurement for either adult males or females, therefore data for each measurement for years 1986-89 were pooled. In 1986-89, the subadult male narwhal were sampled but were not included in the analysis of the adults (Appendix 4). There were only two narwhal sampled in 1983 and these were also not included in the analysis (Appendix 5).

Total body length: Female narwhal sampled during our study attained a maximum length of 494 cm and males 540 cm, which are the largest lengths reported for both males and females (Hay 1984; Mansfield et al. 1975b; Reeves and Tracey (1980); Weaver and Walker (1988b).

There was a significant difference ($P<0.05$) between the mean body lengths of adult

male and female narwhal (Table 7); mean body lengths were 458 cm for males and 413 cm for females. This is similar to that reported by Hay (1984) and Weaver and Walker (1988). The length frequency distributions between male and female narwhal were also significantly different ($P<0.05$) (Fig. 6). Significant differences ($P<0.05$) in mean length depended on the month whales were harvested. Mean lengths differed between areas in July but not in August.

Analysis indicated no significant correlation ($P>0.05$) between body length and any other measurement for either male or female narwhal.

Generally it appears that narwhal harvested from Admiralty Inlet are larger than those reported harvested from Pond Inlet which may be an indication of a separate substock of narwhal. The length frequency distributions for male narwhal between Arctic Bay and Pond Inlet were significantly different ($P<0.05$) but not for females ($P>0.05$) (Table 9). It could also be a result of hunter selection and timing of the hunt.

Other body measurements: Descriptive statistics for body measurements other than body length for adult narwhal are presented in Table 7. All mean measurements (except axillary flipper length) for adult narwhal were significantly different ($P<0.005$) between male and female narwhal. Correlations between the various measurements are presented in Table 8. All mean measurements (except flipper width) of narwhal harvested by Arctic Bay were not significantly different ($P>0.05$) for either males or females from that of narwhal harvested in the Pond Inlet area (Table 9).

Reeves and Tracey (1980) state that flipper lengths of narwhal are between 30-40 cm and are 7-10% of the total body length. This was similar to that found for narwhal harvested from Admiralty Inlet: anterior flipper length ranged between 36-56 cm and was approximately 9% of the total body length.

Tusk: Fifty-eight tusks (55 males and 3 females) were measured for exposed length (Table 7); only two had a small tip of the tusk broken off. One double tusked narwhal was sampled in 1987; the left exposed tusk measured 163 cm length and the right measured 157 cm. Basal circumference was 18 cm and 17 cm for the left and right tusks, respectively.

There was no significant difference ($P>0.05$) between males and females for any mean tusk measurement (Table 7). Analysis indicated a significant correlation ($P<0.001$) between total tusk length and exposed tusk length ($r=0.79$) (Table 8). Mean tusk measurements of narwhal harvested by Arctic Bay were not significantly different ($P>0.05$) for either males or females from that of narwhal harvested in Pond Inlet (Table 9).

Analysis indicated no significant correlation ($P>0.05$) between the exposed tusk length and body length. However Hay (1984), Silverman (1979), Silverman and Dunbar (1980) and Weaver and Walker (1988) found accelerated tusk growth with increases in body growth. Silverman (1979) found that the total tusk length of male narwhal attained a maximum length of 250 cm. This is slightly less than the maximum tusk length of 283 cm recorded for narwhal from Admiralty Inlet.

Muktuk and blubber

There was a significant difference between both the mean axillary ($P<0.001$) and umbilical ($P<0.001$) muktuk measurements of males and females (Table 7). Analysis indicated a significant correlation ($P<0.001$) between axillary muktuk and the umbilical muktuk measurement for both males ($r=0.87$) and females ($r=0.92$) (Table 8).

There was a significant difference between males and females for both the mean axillary ($P<0.001$) and umbilical ($P<0.001$) blubber measurements (Table 7). Analysis indicated a significant correlation ($P<0.05$) between the axillary blubber and the umbilical blubber measurement for both males ($r=0.66$) and females ($r=0.59$) (Table 8).

There were no significant differences ($P>0.05$) in blubber thickness over the summer season for either male or female narwhal sampled from Admiralty Inlet, suggesting that feeding is ongoing during this period or that a high energy food source being used. Weaver and Walker (1988) found no differences in blubber thickness over the summer season for male narwhal and suggested a stable energy balance. However Finley and Gibb (1982) found that blubber thickness of female narwhal declined over the summer season and attributed this to reduced feeding or the additional demands placed on females by calves. Silverman (1979) found that feeding activity decreased in the open water season.

There was a significant difference ($P<0.001$) in blubber (axillary) measurements between Arctic Bay and Pond Inlet for male narwhal. No comparison could be made for females (Table 9).

FEEDING

Thirteen stomachs were examined in 1987: three (23%) were empty and ten contained food (Table 10). Of those stomachs containing food

items, eight contained squid (likely Gonatus sp.), primarily parts and beaks, seven contained fish remains (likely arctic cod), and only one contained shrimp (sp. unknown). The main food item appears to be fish since six of the ten stomachs examined contained >50% fish remains while only four had >50% squid. Sergeant (1979) reported arctic cod, shrimp and squid found in stomachs of narwhal from Pond Inlet. Hay (1984) found the same food items in the stomachs of narwhal he examined from this area and believed the feeding activity was greatest in the spring.

CONCLUSIONS

1. Historic reported harvests of narwhal have fluctuated, likely in response to ice/weather conditions and hunter requirements i.e. muktuk vs ivory.

2. Sex ratio of the harvest varies between hunt phases and between years. The increase in the number of females landed in 1988 is believed due to the interest of the community Co-op in processing muktuk for local resale.

3. Sex composition of the annual harvests for 1986-89 are accurately reported by sub-sampling the landed catch.

4. Annual harvest statistics underestimate the total number of narwhal killed due to the non-reporting of struck and lost (killed) whales.

5. Estimated total kill of narwhal was 138 in 1983, 139 in 1986, 35 in 1987, 131 in 1988 and 125 in 1989. These estimates exceed the reported landed catch by an average 38%. However they do not include an estimate of calves and fetuses lost.

6. Struck loss rates vary between hunt phase. The floe edge hunt has the highest loss rate (32%) and the open water hunt has the lowest (7%).

7. Hunters can reduce losses in all phases of the hunt by waiting until both a good shot and target are available; in the ice hunts, by having a hook and harpoon ready to retrieve the whale. Loss rates in the open water hunt can be reduced by decreasing the number of deep water hunts where whales are more likely to be lost.

8. Loss rates incurred by Arctic Bay hunters are generally lower than those of Pond Inlet hunters in the floe edge and ice crack hunts. Open water hunt loss rates are similar to those of Pond Inlet.

9. Mean body lengths of narwhal sampled differed between the sexes and years as well as between narwhal landed in Arctic Bay and Pond Inlet which may be an indicator of stock discreteness. There was no correlation between body length and any other measurement.

10. Only 18% of tusks examined were reported as having a broken tip. All were from male narwhal. There was a good correlation between exposed tusk length and total tusk length but no correlation with tusk basal circumference. Fifteen percent of all female narwhal examined had a tusk.

11. There was no change in the thickness of blubber over the season in either male or female narwhal. There were strong correlations between muktuk measurements, but weaker ones between blubber thickness measurements.

12. Examination of stomachs indicated narwhal were feeding mainly on arctic cod and squid.

RECOMMENDATIONS

1. Hunters should try to eliminate the number of narwhal mortally wounded and lost whales especially in the ice crack hunts. They should ensure a good shot is available by firing at targets from a distance <20 m. The use of hard point ammunition with high powered rifles should be encouraged.

2. Kill:landed estimators must be calculated for each hunt phase and over a number of years to correct for variations due to ice and weather conditions and hunter proficiency/efficiency. DFO and the Ikajutit HTA should continue to work cooperatively to obtain the necessary hunt event data to calculate these estimators.

3. DFO, in cooperation with the Ikajutit HTA should re-evaluate the tag system to ensure that females harvested are accurately reported. The Ikajutit HTA should continue to provide harvest data including the sex of the narwhal killed and the hunt phase in which it was harvested.

4. DFO should develop and implement a radio/satellite tagging program to determine narwhal movements and possible stock discreteness between Admiralty Inlet and Pond Inlet/ Eclipse Sound.

5. DFO should collect data on the reproductive status of landed females (pregnancy/lactation) which is necessary to adjust for removals of pre-recruits.

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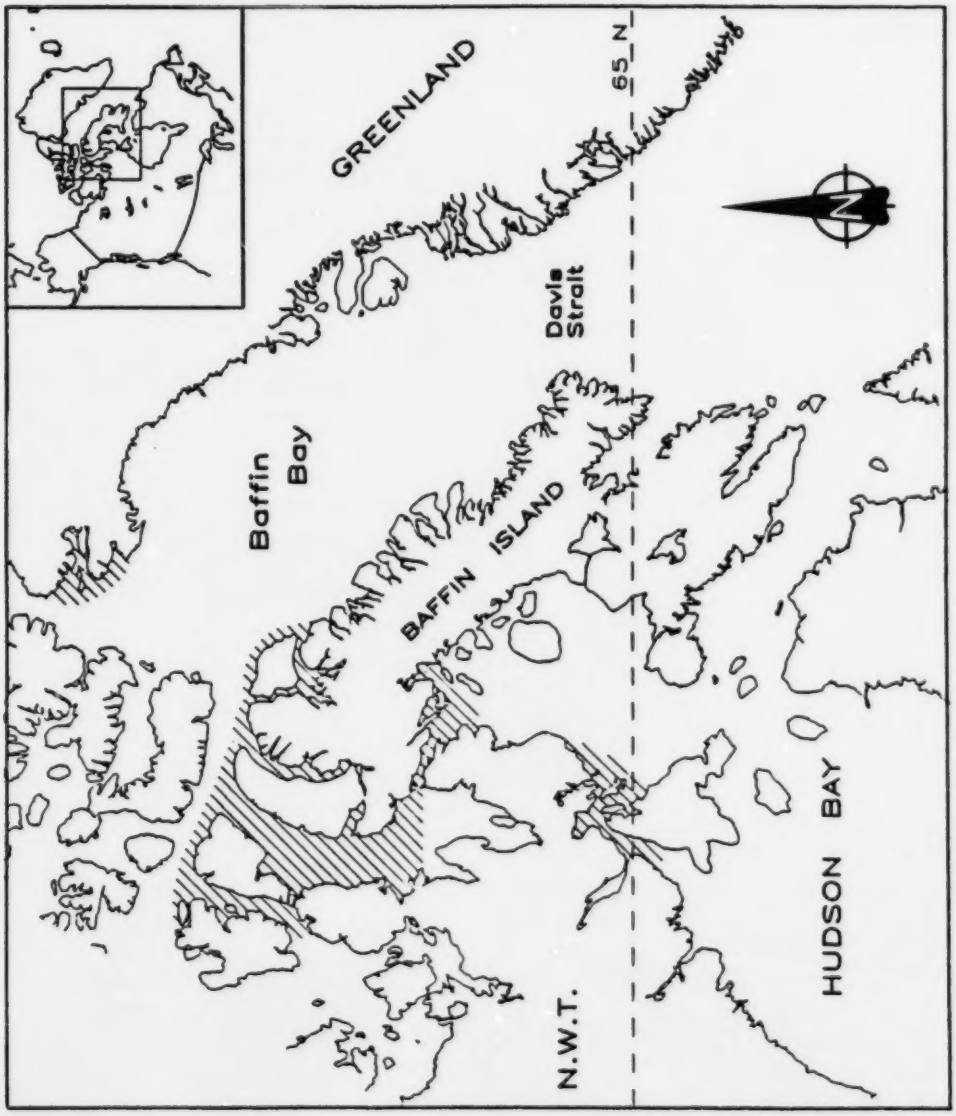


Fig.1. Summering distribution of the three management stocks of narwhal.

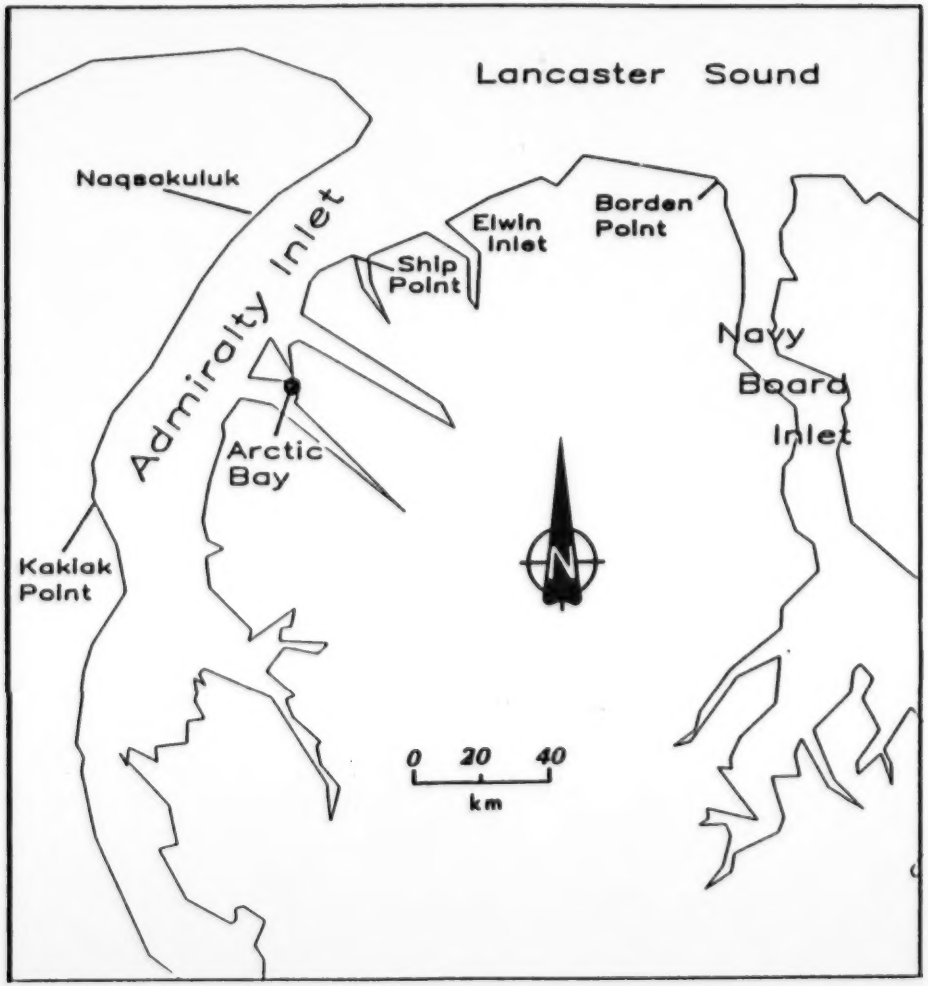


Fig.2. The Admiralty Inlet study area.

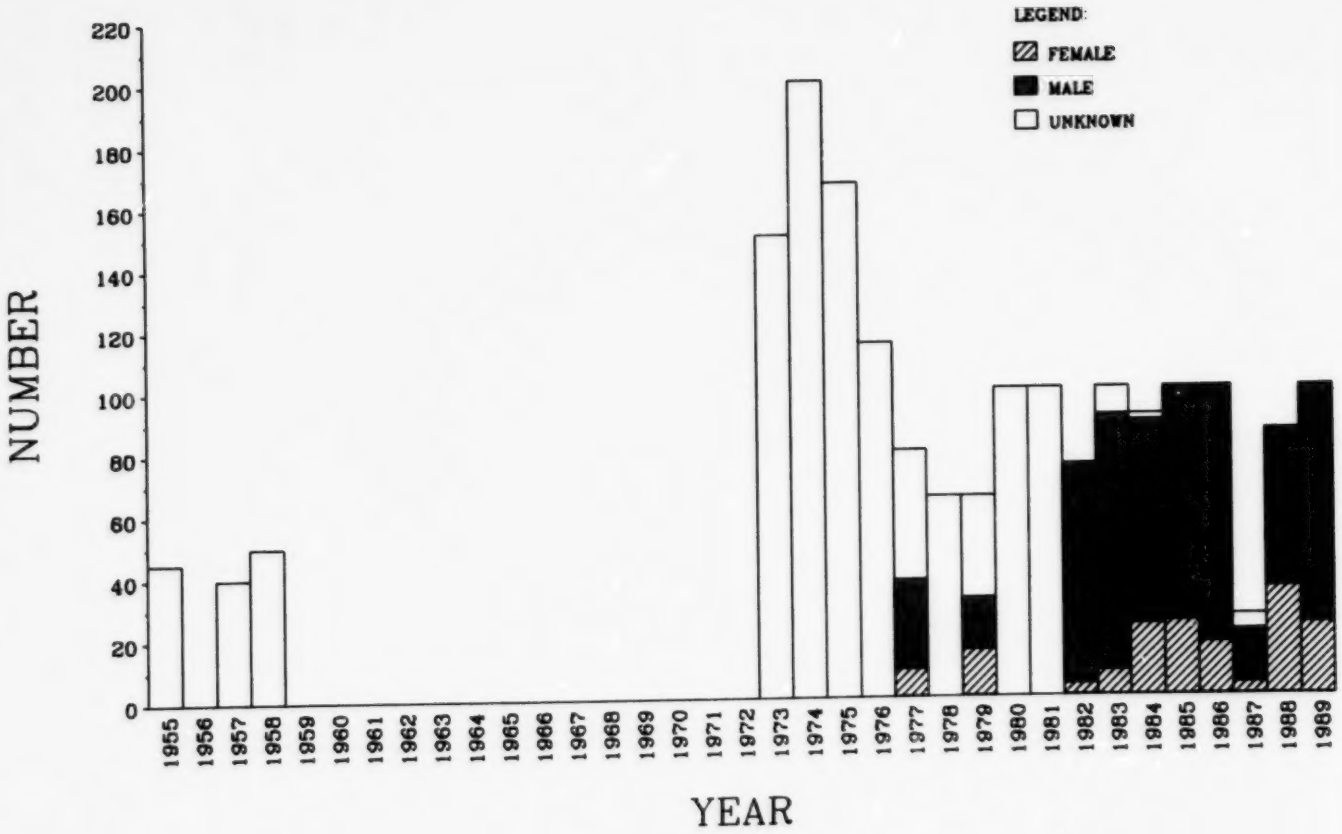
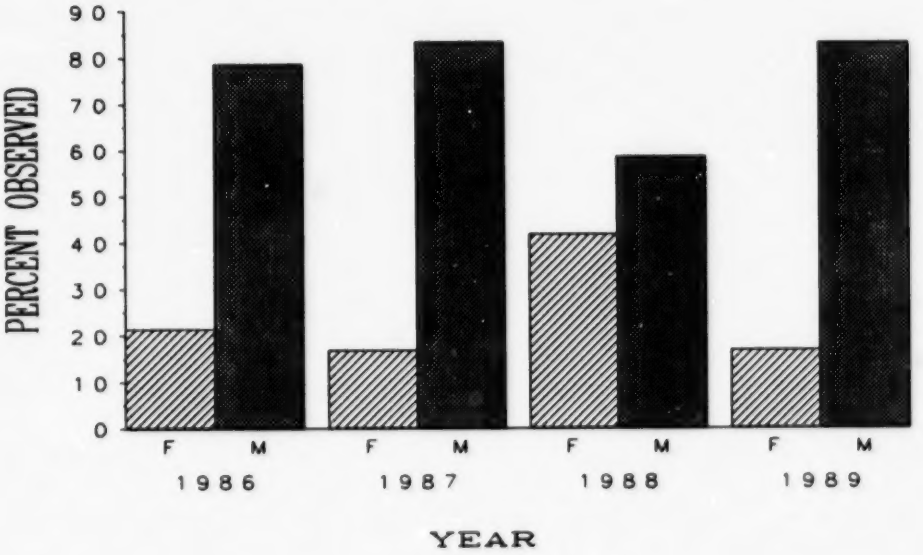


Fig.3. Recorded landings of narwhal by Arctic Bay, 1958-89.



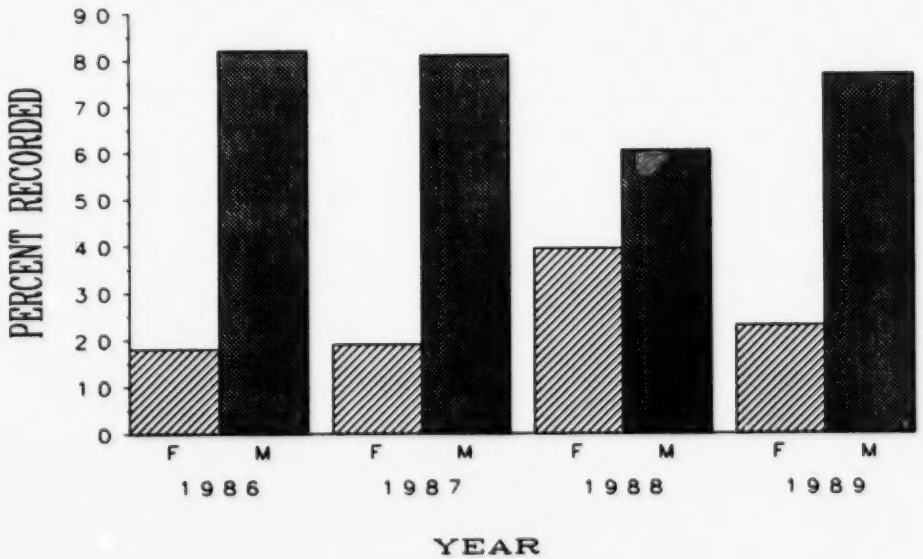


Fig. 4. Recorded and observed landings of male and female narwhal by Arctic Bay, 1986–1989.

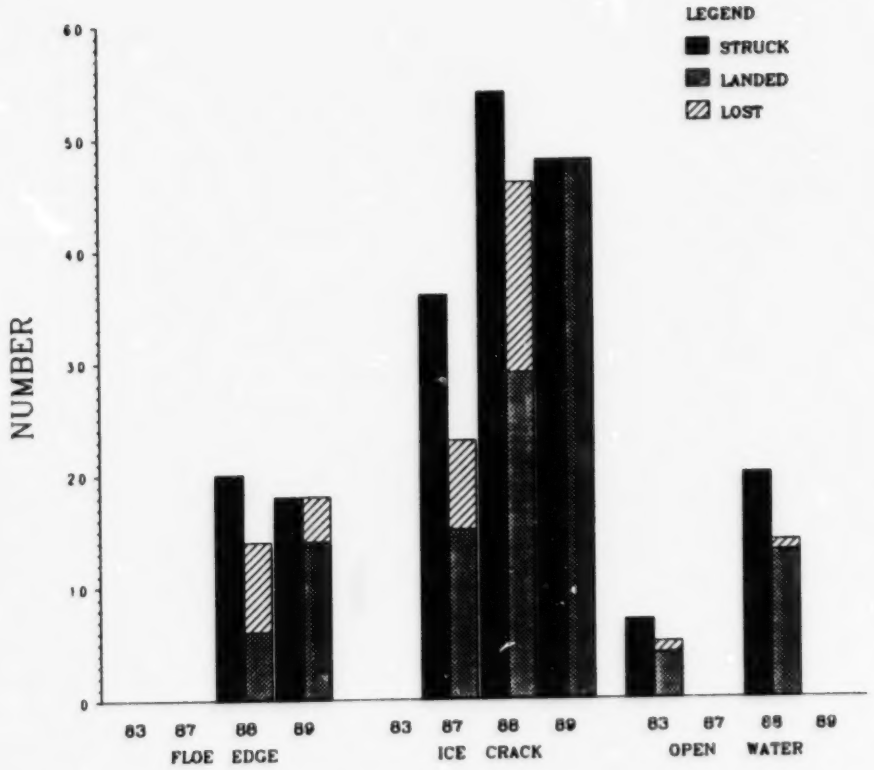


Fig.5. Observed narwhal struck, landed and lost from the Arctic Bay narwhal hunts, 1983 and 1986-89.

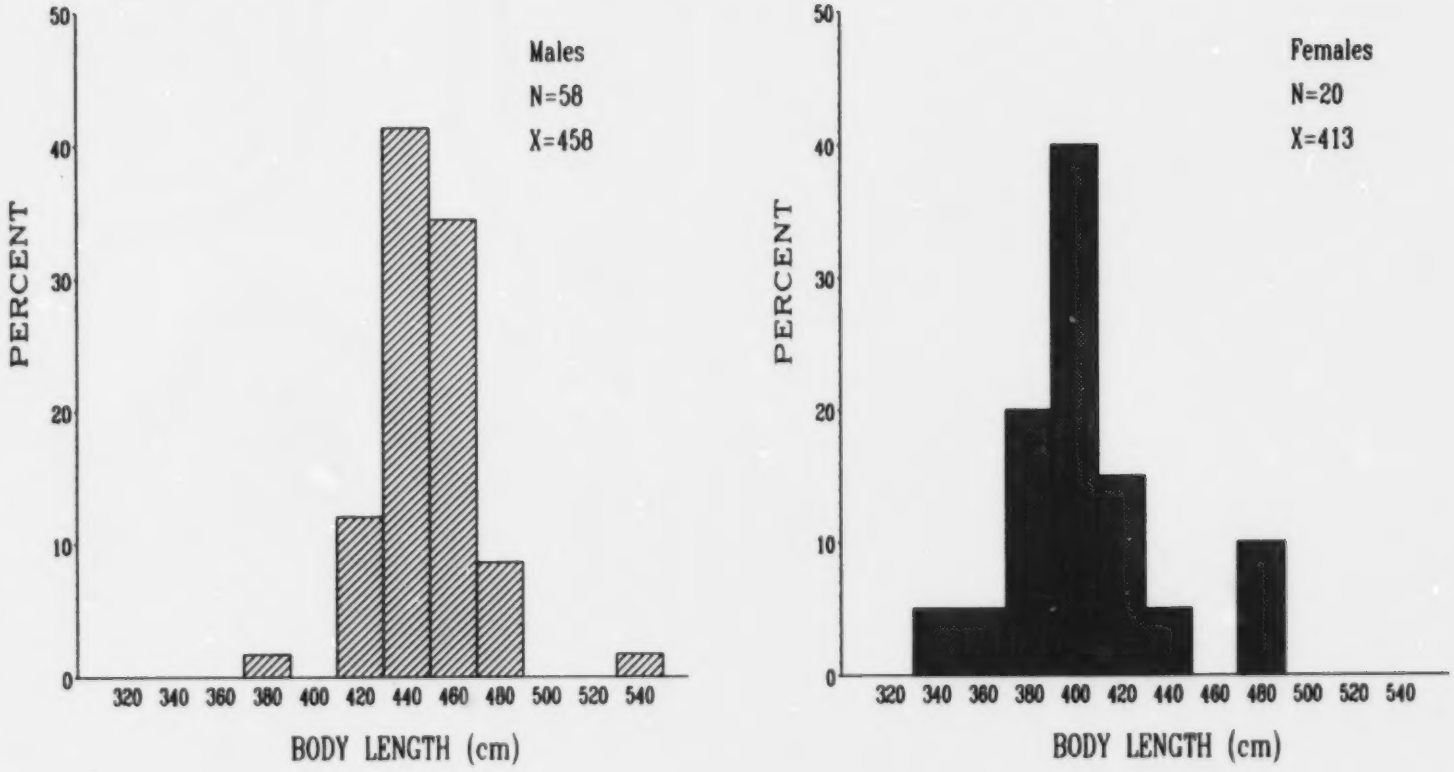


Fig.6. Length frequency distributions of male and female narwhal landed by Arctic Bay, 1986-89.

Table 1. Information on the calibre of rifle and the type of ammunition used during the Arctic Bay narwhal hunt, 1983 and 1987-89.

YEAR	HUNT PHASE	CALIBRE OF FIREARM USED															
		6.5		7mm		223		303		308		30.06		338		375	
		%	AMMO.	%	AMMO.	%	AMMO.	%	AMMO.	%	AMMO.	%	AMMO.	%	AMMO.	%	AMMO.
1983	Floe edge	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Ice crack	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Open water	-	-	-	-	-	-	16.7	-	83.3	-	-	-	-	-	-	-
1987	Floe edge	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Ice crack	13.5	HP	-	-	-	-	80.8	HP	-	-	-	-	-	-	5.8	HP
	Open water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1988	Floe edge	27.3	HP	-	-	-	-	63.6	HP	9.1	SP	-	-	-	-	-	-
	Ice crack	21.4	HP	3.6	SP	-	-	46.4	HP	7.1	H/SP	7.1	SP	-	-	14.3	H/SP
	Open water	19.0	HP	4.8	SP	4.8	HP	47.6	HP	-	-	-	-	9.5	SP	14.3	SP
1989	Floe edge	4.8	HP	-	-	-	-	33.3	HP	4.8	HP	-	-	28.6	SP	28.6	SP
	Ice crack	1.6	SP	3.3	HP	-	-	72.1	HP	-	-	-	-	11.5	SP	11.5	SP
	Open water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TOTAL	11.3	-	2.1	-	0.5	-	63.4	-	2.1	-	1.0	-	7.7	-	11.9	-

HP = Hard point
SP = Soft point
H/SP = 50:50 HP and SP

Table 2. Information on the shots fired and firing ranges for observed hunting events documented during the Arctic Bay narwhal hunt, 1983 and 1987-89.

YEAR	HUNT PHASE	NO. EVENTS		NO. HUNTERS			NARWHAL STRUCK				
		TOTAL	NARWHAL STRUCK	TOTAL	FIRED SHOTS	STRUCK NARWHAL	MEAN NO. STRUCK	MEAN NO. SHOTS FIRED	DISTANCE FIRED FROM		
									MEAN	MINIMUM	MAXIMUM
1983	Floe edge	-	-	-	-	-	-	-	-	-	-
	Ice crack	-	-	-	-	-	-	-	-	-	-
	Open water	7	4	7	7	4	1.0	1.0	22.9	5.0	60.0
1987	Floe edge	-	-	-	-	-	-	-	-	-	-
	Ice crack	24	18	61	34	29	1.4	2.5	3.3	2.3	4.6
	Open water	-	-	-	-	-	-	-	-	-	-
1988	Floe edge	7	7	11	11	11	2.9	3.4	5.9	1.2	12.2
	Ice crack	24	24	29	29	29	2.3	2.5	13.5	3.0	36.6
	Open water	19	17	21	21	19	1.2	1.2	12.2	2.1	305.0
1989	Floe edge	21	21	21	21	21	1.0	1.3	13.1	2.7	45.7
	Ice crack	49	49	61	61	61	1.4	1.8	10.6	1.2	45.7
	Open water	-	-	-	-	-	-	-	-	-	-

Table 3. Sex ratio of narwhal harvested in each hunt phase during the annual subsistence hunt in Arctic Bay, 1983-89.

YEAR	SEX RATIO (male:female)			
	FLOE EDGE	ICE CRACK	OPEN WATER	TOTAL
1983	1:0.0	1:<0.1	1:0.7	1:0.1
1984	1:6.0	1:0.3	0:1.0	1:0.4
1985	-	1:0.3	-	1:0.3
1986	1:0.0	1:0.2	1:1.0	1:0.2
1987	-	1:0.1	1:0.4	1:0.2
1988	1:1.1	1:0.5	1:0.9	1:0.7
1989	1:0.4	1:0.2	1:1.2	1:0.3

Table 4. Harvest analysis for each phase of the Arctic Bay narwhal hunt, 1983 and 1987-89.

YEAR	HUNT PHASE	STRUCK	LANDED	STRUCK BUT LOST[1]						MINIMUM TOTAL KILLED	STRUCK[2] LOSS RATE (%)
				SW		MW		SUNK			
				No.	%	No.	%	No.	%		
1983	Floe edge	-	-	-	-	-	-	-	-	-	-
	Ice crack	-	-	-	-	-	-	-	-	-	-
	Open water	7	4	2	28.5	1	14.3	0	-	5	14.3
	TOTAL	7	4	2	28.5	1	14.3	0	-	5	14.3
1987	Floe edge	-	-	-	-	-	-	-	-	-	-
	Ice crack	36	15	13	36.1	8	22.2	0	-	23	22.2
	Open water	-	-	-	-	-	-	-	-	-	-
	TOTAL	36	15	13	36.1	8	22.2	0	-	23	22.2
1988	Floe edge	20	6	6	30.0	1	5.0	7	35.0	14	40.0
	Ice crack	54	29	8	14.8	10	18.5	7	13.0	46	31.5
	Open water	20	13	6	30.0	1	5.0	0	-	14	5.0
	TOTAL	94	48	20	21.3	12	12.8	14	14.9	74	27.7
1989	Floe edge	21	16	-	-	1	4.8	4	19.0	21	23.8
	Ice crack	70	50	7	10.0	5	7.1	8	11.4	63	18.6
	Open water	-	-	-	-	-	-	-	-	-	-
	TOTAL	91	66	7	7.7	6	6.6	12	13.2	84	19.8
Total	Floe edge	41	22	6	14.6	2	4.9	11	26.8	35	31.7
	Ice crack	160	94	28	17.5	23	14.4	15	9.4	132	23.8
	Open water	27	17	8	29.6	2	7.4	-	-	19	7.4

[1] SW = superficially wounded, MW = mortally wounded, SUNK = killed but sunk.
[2] MW + SUNK.

Table 5. Estimated total kill, by hunt phase and year, for the Arctic Bay narwhal hunt, 1983 and 1986-89.

YEAR	HUNT PHASE	KILL:LANDED ESTIMATOR	REDUCED-BIAS KILL:LANDED ESTIMATOR	TOTAL RECORDED LANDED	ESTIMATED TOTAL KILL
1983	Floe edge	-	1.56*	3	5
	Ice crack	-	1.41*	80	113
	Open water	1.25	1.18	17	20
	TOTAL			100	138
1986	Floe edge	-	1.56*	1	2
	Ice crack	-	1.41*	91	128
	Open water	-	1.11*	8	9
	TOTAL	-		100	139
1987	Floe edge	-	-	0	0
	Ice crack	1.53	1.50	15	23
	Open water	-	1.11*	11	12
	TOTAL			26	35
1988	Floe edge	2.33	2.08	15	31
	Ice crack	1.59	1.56	50	78
	Open water	1.08	1.07	21	22
	TOTAL			86	131
1989	Floe edge	1.31	1.29	19	25
	Ice crack	1.26	1.26	70	88
	Open water	-	1.11*	11	12
	TOTAL			100	125
Total	Floe edge	1.59	1.56		
	Ice crack	1.40	1.41		
	Open water	1.12	1.11		

* Total (pooled) estimator.

Table 6. Observed landed catch composition in each phase of the Arctic Bay narwhal hunt, 1986-89.

YEAR	HUNT PHASE	MALES			FEMALES			% FEMALE LANDED
		ADULT	IMMATURE	TOTAL	ADULT	IMMATURE	TOTAL	
1986	Floe edge	-	-	-	-	-	-	-
	Ice crack	11	-	11	3	-	3	21.4
	Open water	-	-	-	-	-	-	-
1987	Floe edge	-	-	-	-	-	-	-
	Ice crack	9	1	10	2	-	2	16.7
	Open water	-	-	-	-	-	-	-
1988	Floe edge	-	-	-	-	-	-	-
	Ice crack	11	-	11	5	-	5	31.3
	Open water	1	2	3	5	-	5	62.5
1989	Floe edge	7	-	7	1	-	1	12.5
	Ice crack	17	1	18	4	-	4	18.2
	Open water	-	-	-	-	-	-	-

Table 7. Morphometric measurements (cm), by sex, for adult narwhal sampled from the Arctic Bay narwhal hunt, 1986-89.

Measurement	MALES				FEMALES				P
	N	Mean	Range	Std. dev.	N	Mean	Range	Std. dev.	
Body length	56	458	396-540	20.3	20	413	356-494	33.1	<0.001
Fluke width	54	106	61-130	8.8	20	92	74-115	8.9	<0.001
Axillary girth	54	255	200-286	16.7	19	229	202-286	21.0	<0.001
Umbilical girth	52	282	221-366	21.3	19	245	197-271	18.8	<0.001
Flipper length (anteror)	52	41	36-47	2.5	20	41	36-56	4.3	>0.050
Flipper length (axilla)	52	36	29-41	2.6	20	34	28-38	2.8	<0.010
Flipper width	52	22	15-30	2.6	20	20	15-28	3.3	<0.010
Exposed tusk length	55	173	76-245	29.2	3	149	102-231	71.0	>0.050
Total tusk length	44	213	107-283	32.9	3	175	130-259	73.1	>0.050
Tusk basal circumference	49	20	15-25	2.4	2	22	15-28	9.2	>0.050
Muktuk (axillary)	52	1.2	0.4- 1.6	0.2	20	1.2	0.5-1.6	0.3	>0.050
Muktuk (umbilical)	53	1.2	0.5- 1.6	0.3	20	1.2	0.7-1.7	0.3	>0.050
Blubber (axillary)	51	6.7	3.1-10.3	1.3	19	5.2	1.3-7.6	1.5	<0.001
Blubber (umbilical)	52	6.4	2.3- 8.3	1.0	19	5.2	1.3-7.6	1.5	>0.001

Table 8. Relationship between morphometric measurements, by sex, of narwhal sampled from the Arctic Bay narwhal hunt, 1986-89.

Independent Variable	Dependent Variable	Males					Females				
		N	Correlation Coefficient (r)	Estimate of		P	N	Correlation Coefficient (r)	Estimate of		P
				Intercept	Slope				Intercept	Slope	
Axillary girth	Umbilical girth	51	0.51	117.777	0.644	<0.001	17	0.76	88.212	0.684	<0.001
Flipper length (anterior)	Flipper length (axilla)	51	0.73	5.898	0.742	<0.001	19	0.65	16.969	0.426	<0.005
Exposed tusk	Total tusk length	43	0.79	57.226	0.894	<0.001	-	-	-	-	-
Muktuk (axillary)	Muktuk (umbilical)	51	0.87	0.167	0.940	<0.001	19	0.92	0.030	1.016	<0.001
Blubber (axillary)	Blubber (umbilical)	50	0.66	2.955	0.512	<0.001	17	0.59	0.539	0.829	<0.050

Table 9. Comparison of morphometric measurements (cm), by sex, for adult narwhal from Arctic Bay (1986-89) and Pond Inlet hunts (1982-83).

Measurement	Males						P	Females						P
	Arctic Bay			Pond Inlet				Arctic Bay			Pond Inlet			
	N	Mean	Std. Error	N	Mean	Std. Error		N	Mean	Std. Error	N	Mean	Std. Error	
Body length	56	458	2.849	37	435	3.724	<0.001	20	413	7.407	20	381	6.872	<0.001
Fluke width	54	106	1.203	36	107	1.366	>0.050	20	92	1.984	17	91	2.609	>0.050
Axillary girth	54	255	2.274	27	260	3.380	>0.050	19	229	4.809	13	222	6.919	>0.050
Umbilical girth	52	282	2.951	34	282	3.436	>0.050	19	245	4.304	13	240	8.322	>0.050
Flipper length (anterior)	52	41	0.350	34	42	1.346	>0.050	20	40	0.966	17	38	0.840	>0.050
Flipper length (axilla)	52	36	0.355	32	36	0.853	>0.050	20	34	0.635	13	35	0.796	>0.050
Flipper width	52	22	0.354	32	21	0.244	<0.050	20	20	0.738	14	18	0.512	<0.050
Exposed tusk length	55	173	3.940	36	162	4.962	>0.050	3	149	41.005	1	100	-	>0.050
Total tusk length	44	213	4.959	10	220	7.793	>0.050	3	175	42.191	-	-	-	-
Tusk basal circumference	49	20	0.348	36	21	0.503	>0.050	2	22	6.500	1	13	-	>0.050
Blubber (axillary)	51	6.66	0.187	9	7.95	0.367	<0.001	-	-	-	-	-	-	-

Table 10. Occurrence of various food items in narwhal stomachs, Arctic Bay, 1987.

No. Stomachs Containing Food	No. Stomachs Containing			No. Stomachs Containing > 50%		
	Squid	Fish	Shrimp	Squid	Fish	Shrimp
10	8	7	1	4	6	0

Appendix 1. Data sheet used for the collection of narwhal hunt event data.

Government of Canada / Gouvernement du Canada
Fisheries and Oceans / Pêches et Océans

Fish and Marine Mammal Management

HUNTING CENSUS FORM

DATE: _____
day / mo / yr

Weather:
- Sunny ☐
- Partly Cloudy ☐
- Cloudy ☐
- Rain ☐
- Snow ☐

Hunt:
- Floe Edge ☐
- Ice Crack ☐
- Open Water ☐

Water:
- Ripples (1–6 inches) ☐
- Small Waves (1/2–1 foot) ☐
- Rough (1–2 ft) ☐
- Storm (over 2 ft) ☐

Location: _____

Species: _____

Name of hunter(s): _____

Animals shot at: ____
Animals struck: ____
Animals lost
1. Superficially wounded: ____
2. Mortally wounded: ____
Animals sunk: ____
Animals landed: ____

Total shots fired: ____
Calibre of rifle(s): ____
____

Type of ammunition:
1. Hard point ☐
2. Soft point ☐

Distances animals shot from: _____
Hunt time: Start ____ Finish ____

Indicate where animal was struck.

Data recorded by: Hunter ☐ Monitor ☐

Recorder name: _____

Appendix 2. Data sheet used for the collection of narwhal biological data.

Government of Canada / Gouvernement du Canada
Fisheries and Oceans / Pêches et Océans

Fish and Marine Mammal Management

CETACEAN DATA SHEET

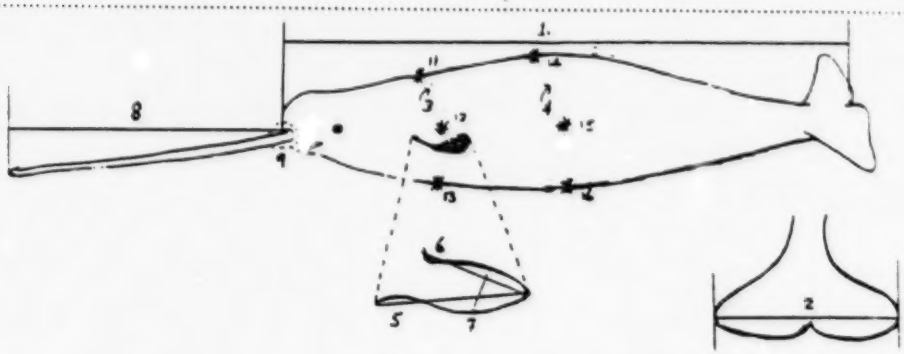
Sample #: _____ Date _____ (day / mo / yr)
Species: _____
Location: _____
Lat: _____ (deg min sec) Long: _____ (deg min sec)

Sex: Male ☐ Female ☐

Total length:	(1)	cm
Fluke width:	(2)	cm
Girth at armpit:	(3)	cm
Girth at navel:	(4)	cm
Flipper length: (right side)		
– anterior origin to tip	(5)	cm
– axilla to tip	(6)	cm
– maximum width	(7)	cm
Tusk: – exposed length	(8)	cm
– basal circum.	(9)	cm
– total length	(10)	cm

Blubber Thickness

		Muktuk (cm)	Blubber (cm)
at armpit:	(11)–back		
	(12)–side		
	(13)–belly		
at navel:	(14)–back		
	(15)–side		
	(16)–belly		



Data recorded by: Hunter ☐ Monitor ☐

Recorder Name _____

Appendix 3. Morphometric measurements (cm) for subadult male narwhal sampled from the Arctic Bay narwhal hunt, 1986-89.

	N	Mean	Range	Std. dev.
Body length	4	333	290-368	32.2
Fluke width	5	83	75-92	7.3
Girth - axillary	4	200	183-212	12.7
- umbilical	4	202	185-225	17.8
Flipper length - anterior	5	36	35-38	1.1
- axilla	5	31	29-33	1.6
Flipper width	5	18	17-20	1.3
Tusk length - exposed	4	72	19-150	63.4
- total	4	101	44-184	68.5
Tusk basal circumference	4	1.1	0.7-1.7	0.5
Muktuk - axillary	2	1.11	0.97-1.27	0.2
- umbilical	2	1.27	1.13-1.40	0.2
Blubber - axillary	2	6.68	5.73-7.63	1.3
- umblical	2	6.15	5.33-6.97	1.2

Appendix 4. Morphometric measurements (cm) for narwhal from the Arctic Bay narwhal hunt, 1983.

	Males		Females	
	N	Mean	N	Mean
Body length	1	319.00	1	396.00
Fluke width	1	80.00	1	94.00
Girth - axillary	1	95.00	1	118.00
- umbilical	1	105.00	1	124.00
Flipper length - anterior	1	37.00	1	41.00
- axilla	1	29.00	1	35.00
Flipper width	1	16.00	1	18.00
Tusk length - exposed	1	43.00	-	-
- total	-	-	-	-
Tusk basal circumference	1	1.10	-	-
Muktuk - axillary	1	1.17	1	1.43
- umbilical	1	1.37	1	1.20
Blubber - axillary	1	6.37	1	6.27
- umblical	1	4.87	1	6.63